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Bitcoin: An inflation hedge but not a safe haven

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A R T I C L E   I N F O

A B S T R A C T

During the recent COVID-19 pandemic, many commonalities shared by Bitcoin and gold raise the question of whether Bitcoin can hedge inflation or provide a safe haven as gold often does. By estimating a Vector Autoregression (VAR) model, we provide systematic evidence on the relationship among inflation, uncertainty, and Bitcoin and gold prices. Bitcoin appreciates against inflation (or inflation expectation) shocks, confirming its inflation-hedging property claimed by investors. However, unlike gold, Bitcoin prices decline in response to financial uncertainty shocks, rejecting the safe-haven quality. Interestingly, Bitcoin prices do not decrease after policy uncertainty shocks, partly consistent with the notion of Bitcoin's independence from government authorities. We also find an interesting asymmetry in the drivers of Bitcoin price dynamics between the bullish and bearish market. The main findings hold with or without the COVID-19 pandemic episode.

1. Introduction

Since the global financial crisis in 2008, various types of cryptocurrencies, including Bitcoin, have emerged as new forms of digital money and payment structures that allow users to make peer-to-peer transactions without the intervention of financial intermediaries (Nakamoto, 2008). While Bitcoin has become a significant interest of not only investors but also academics and policymakers, existing theoretical and empirical attempts have not reached a consensus about its nature. Recently, the COVID-19 pandemic asked important questions regarding the nature of Bitcoin again. Does Bitcoin hedge inflation pressure caused by government stimulus measures? Does Bitcoin act as a safe haven for investors during market turmoil or heightened uncertainty? Recent studies have partly answered these questions but have not reached a consensus (Conlon and McGee, 2020; Dutta et al., 2020; Mariana et al., 2021).[1]

We contribute to this emerging literature and contemporary discussions by providing systemic evidence on the relationship among inflation (or inflation expectation), uncertainty, and Bitcoin prices. Despite the rapid expansion of empirical studies, many analyses have focused on the statistical properties of Bitcoin to understand its herding behavior or determine its safe-haven status, mostly from a portfolio diversification perspective (e.g., Dyhrberg, 2016; Bouri et al., 2017; Shahzad et al., 2019; Smales, 2019; Wang et al., 2019).

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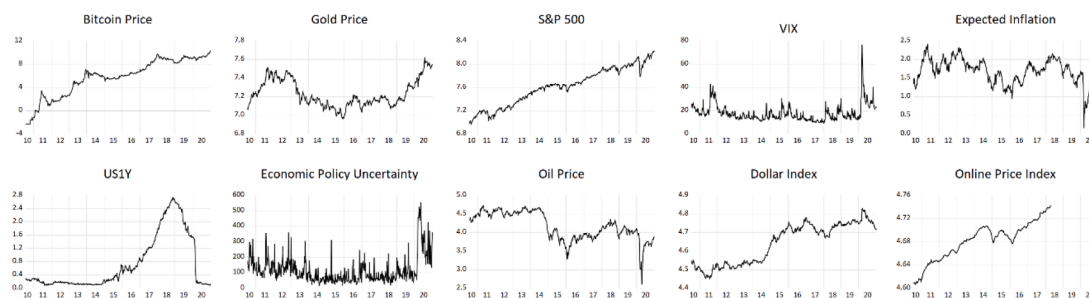*E-mail addresses:* sangyupchoi@yonsei.ac.kr (S. Choi), junhyeok.shin@yonsei.ac.kr (J. Shin).

[1] For example, while Mariana et al. (2021) argue that Bitcoin exhibits short-term safe haven properties during the pandemic, Conlon and McGee (2020) conclude that Bitcoin is not a safe haven for the majority of international equity markets examined.

Note: This graph plots the time series of Bitcoin prices and other macroeconomic and financial variables. The natural logarithm is taken to Bitcoin and gold prices, S&P 500, oil prices, the dollar index, and the OPI.

Fig. 1. The evolution of the Bitcoin prices and other variables.
Note: This graph plots the time series of Bitcoin prices and other macroeconomic and financial variables. The natural logarithm is taken to Bitcoin and gold prices, S&P 500, oil prices, the dollar index, and the OPI.

Moreover, although few studies based on the money demand theory provide a link between Bitcoin prices and inflation (Ciaian et al., 2016), this link has not been tested empirically to our knowledge.[2] Given that many investors consider Bitcoin as an inflation hedge, especially during the recent pandemic (Bloomberg, 2020), the high-frequency analysis on the relationship between inflation and Bitcoin prices provides timely policy implications.

Against this background, analysis of the response of Bitcoin prices to shocks to uncertainty and inflation within a Vector Autoregression (VAR) framework using high-frequency data provides a more qualified metric for gaging the nature of Bitcoin from a macroeconomic perspective. Considering the well-known safe-haven and inflation-hedging property of gold, as well as its similarities to Bitcoin (e.g., exogenous supply, pseudo-medium of exchanges, and speculative demand),[3] we compare the response of Bitcoin prices with that of gold prices to the same kind of shocks, which ease interpretation of our findings.[4]

We find that Bitcoin prices decrease significantly in response to financial uncertainty shocks—measured by the VIX, suggesting that Bitcoin is not a safe-haven asset. However, Bitcoin prices do not decline in response to policy uncertainty shocks—proxied by Economic Policy Uncertainty (EPU) constructed by Baker et al. (2016), lending support to the notion of Bitcoin's independence from government authorities. Bitcoin appreciates against positive inflation and inflation expectation shocks, suggesting its inflation-hedging property that has not been confirmed in the existing literature. Overall, these responses to the structural shocks sharply differ from those of gold prices to the same shocks, which strongly repudiate the recent claim that Bitcoin is the "digital gold."

2. Empirical analysis

2.1. Data

We estimate the VAR model at a weekly frequency to understand the short-run effect of uncertainty and inflation shocks on Bitcoin prices. We use the S&P 500 index to capture overall financial market conditions and test the robustness of our findings using the world stock market index. We measure the degree of uncertainty in the economy by the VIX and EPU index.[5] They capture uncertainty

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[2] For example, Ciaian et al. (2016) build a simple conceptual framework of Bitcoin price formation by borrowing Barro's (1979) model for gold standards and test its predictions. Although the opportunity cost of holding Bitcoin crucially depends on inflation under the standard money demand theory, Ciaian et al. (2016) instead use the exchange rate between the U.S. dollar and Euro as a measure of the general price level due to the lack of data on prices at such a high frequency. However, the exchange rate can be driven by factors other than inflation and is too volatile to be rationalized by the changes in economic fundamentals.

[3] However, note that there exists a fundamental difference between gold and Bitcoin. While the former has intrinsic value and is used as an intermediate good in production, the latter (arguably) has no intrinsic value.

[4] There is a vast empirical literature on the safe-haven or inflation-hedging quality of gold (e.g., Economist, 2005; Baur and McDermott, 2010; Joy, 2011; Reboredo, 2013).

[5] The VIX is a measure of market expectations of near-term volatility, as implied by S&P 500 stock index option prices, which becomes a standard measure of uncertainty in financial markets. The EPU index captures the uncertainty of "who will make economic policy decisions, what economic policy actions will be undertaken and when they will be enacted, the economic effects of past, present and future policy actions, and uncertainty induced by policy inaction." The index has been widely used in recent studies as an alternative to the VIX—the most popular uncertainty measure based on financial market data. In constructing the index, Baker et al. (2016) mainly adopted a narrative approach and utilized the news coverage of policy-related economic uncertainty. They counted the articles appearing in every newspaper containing terms related to economic and policy uncertainty. Each article should contain terms related to the three categories of uncertainty, economy, and policy to meet the criteria for inclusion.

Table 1
Summary statistics.

	Bitcoin Prices (%)	Gold Prices (%)	S&P 500 (%)	VIX	π^e(%)	US1Y (%)	EPU	WTI	Dollar Index	OPI
Mean	2.337	0.087	0.232	17.718	1.689	0.724	116.602	−0.085	0.031	0.033
Median	0.797	0.154	0.449	15.590	1.710	0.260	90.420	0.067	0.001	0.027
Max	112.601	8.230	10.717	76.450	2.410	2.740	553.210	46.233	5.006	0.585
Min	−70.852	−12.398	−13.379	9.150	0.160	0.090	18.040	−48.099	−2.150	−0.595
Std. Dev.	16.161	2.182	2.144	7.296	0.323	0.806	86.071	5.981	0.719	0.123
Observations	539	539	539	539	539	539	539	539	539	400

Note: This table shows summary statistics of Bitcoin prices and other macroeconomic and financial variables. Bitcoin prices, gold prices, S&P 500, WTI, Dollar Index, and the Online Price Index are log-differenced. The VIX, expected inflation, the one-year Treasury bill rate, and the Economic Policy Uncertainty Index are in level.

regarding different dimensions (financial vs. policy) of the economy.[6]

Motivated by the prediction of the money demand theory on Bitcoin or gold price formulation (Barro, 1979; Ciaian et al., 2016), we employ both inflation expectations—measured by the difference between the five-year nominal treasury yield and the five-year TIPS (Treasury Inflation-Protected Securities) yield—and the online price index (OPI) constructed by Cavallo and Rigobon (2016) to measure inflation pressures at a high frequency.[7] While investigating the prices on goods sold online is particularly relevant for capturing the inflation-hedging demand of Bitcoin, the OPI has never been used to understand the Bitcoin price behavior. Lastly, we use the one-year Treasury bill rate to measure the stance of monetary policy.

The data used for the following empirical analysis include weekly (Wednesday) observations between July 21, 2010, and December 31, 2020 (a total of 539 weekly observations).[8] The beginning date of the sample is governed by the introduction of Bitcoin exchanges. Fig. 1 plots the evolution of the main variables used in the empirical analysis

Table 1 provides summary statistics on weekly compounded (log) returns on Bitcoin prices and the other variables. As expected, Bitcoin prices during the sample period are characterized by a strong upward trend as well as excessive volatility. Table A.1 in Appendix summarizes the correlations between the main variables of interest. Bitcoin does not show any strong unconditional correlations with other financial assets, somewhat consistent with previous studies concluding that Bitcoin can be used as a hedge against investment in other financial assets such as stocks and bonds (Dyhrberg, 2016; Bouri et al., 2017). We delve into a more formal analysis in the following section to qualify the suggestive evidence.

2.2. Vector autoregressions model

To test the effect of various structural shocks on Bitcoin prices, the baseline VAR model includes six variables and a linear and quadratic trend: the log of the U.S. stock market index, the VIX index, five-year-ahead inflation expectations,[9] the one-year U.S. Treasury bill rate, the log of gold prices, and the log of Bitcoin prices. ADF unit root test results in Table A.2 in Appendix indicate that Bitcoin and gold prices and the one-year U.S. Treasury bill rate are nonstationary, whereas other variables are stationary. We model the data in (log) levels to preserve the potential cointegrating relationships among the variables.[10]

We impose structural assumptions on the variables equivalent to Cholesky identification arranging of the variables in the above order, implying that a variable is affected by contemporaneous changes in the variables listed before it, whereas this variable is exogenous to the variables listed after it. Given the small share of Bitcoin in financial markets, it is reasonable to treat Bitcoin prices as the least exogenous variable in the VAR system.[11] The identifying assumption on the rest of the variables is largely compatible with the vast literature on the monetary VAR model (e.g., Christiano et al., 2005) augmented with uncertainty shocks, in the sense that the second-moment shock to the economy is purged of the first-moment shock (e.g., Bloom, 2009).

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[6] The recent finding that VIX is an important driver of risky asset prices across the globe and international capital flows (Rey, 2015) further justifies its use for testing the safe-haven property of Bitcoin. The recent episodes of the Brexit and the U.S. presidential election demonstrate how empirical proxies for each uncertainty can diverge dramatically from one another. We choose the U.S. EPU index because of its high correlation with the world EPU index and its availability at a daily frequency.

[7] The daily OPI is calculated with price data from numerous websites across the internet. The prices collected by automatized "scraping" programs are put together in a way similar to how the usual CPI is produced (see Figure A.1 in Appendix).

[8] Although daily data are also available for every variable, we choose a weekly frequency to minimize the persistence in the data and the influence of time-zone differences, which is standard in the finance literature. We test the robustness of our findings using daily data.

[9] In the previous draft, we analyzed inflation based on the high-frequency online price index. Since this index is not available for the pandemic period, we used inflation expectations for the baseline analysis and tested the robustness of our findings using the OPI.

[10] A large body of literature on this issue suggests that it is still desirable to estimate the VAR model in levels, even if the variables have unit roots (Sims et al., 1990). We still test the robustness of the main dynamic relationship we found by estimating the Vector Error Correction Model and confirm that the results hardly change. To save space, this result is available upon request.

[11] Gold prices are placed before Bitcoin prices because markets for trading gold are much larger, more established, and more liquid than the Bitcoin market (i.e., information is likely to flow from the gold market to the Bitcoin market).
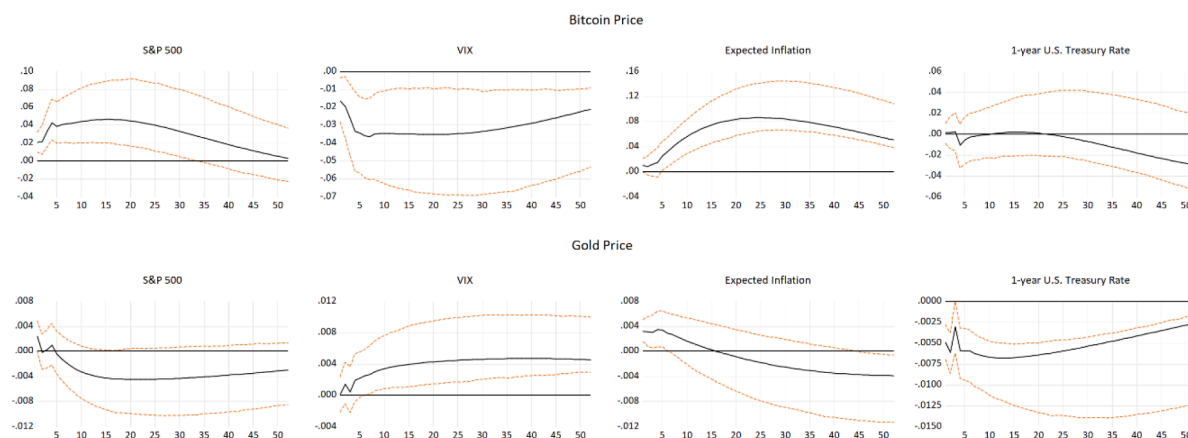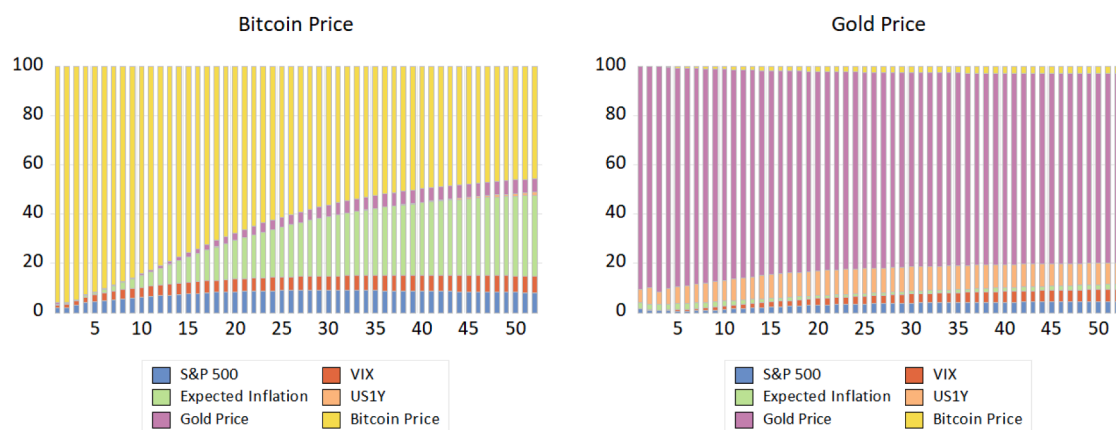
Fig. 2. The response of Bitcoin and gold prices: baseline model
Note: This graph shows impulse responses of Bitcoin and gold prices to the one-standard-deviation shock in other variables and their 90% confidence bands from the six-variable VARs for the sample period between July 21, 2010, and December 31, 2020. The units of the horizontal axes are a week. The graphs on the top illustrate the response of Bitcoin prices, and the graphs on the bottom illustrate the response of gold prices.

Note: This graph shows forecast error variance decomposition of Bitcoin and gold prices for the sample period between July 21, 2010, and December 31, 2020. The units of the horizontal axes are a week.

Fig. 3. Forecast error variance decomposition of Bitcoin and gold prices
Note: This graph shows forecast error variance decomposition of Bitcoin and gold prices for the sample period between July 21, 2010, and December 31, 2020. The units of the horizontal axes are a week.

2.3. Main results

The top panel in Fig. 2 shows the main empirical findings in this paper.[12] First, Bitcoin prices increase significantly in response to a positive shock to the stock market, suggesting that Bitcoin does not serve as a hedge for investment in stock markets, in contrast to the results using GARCH models (e.g., Dyhrberg, 2016). Second, Bitcoin prices decline significantly in response to the shock to the VIX. The one standard deviation increase in the VIX is followed by a more than 7% decline in Bitcoin prices after three months, corroborating the empirical evidence rejecting the safe-haven property using various statistical methodologies (e.g., Bouri et al., 2017; Shahzad et al., 2019; Smales, 2019; Conlon and McGee, 2020). Third, Bitcoin prices increase significantly after a positive inflation shock, suggesting that Bitcoin could be a useful hedge against inflation. Lastly, Bitcoin prices do not respond much to the shock to the nominal interest

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[12] For each impulse response function, the 90% bootstrap confidence intervals are plotted. Figure A.2 in Appendix plots the entire set of impulse response functions for a comprehensive picture. We confirm that our findings are robust for the exclusion of gold prices in the VAR system (i.e., the five-variable VARs). The results are available upon request.
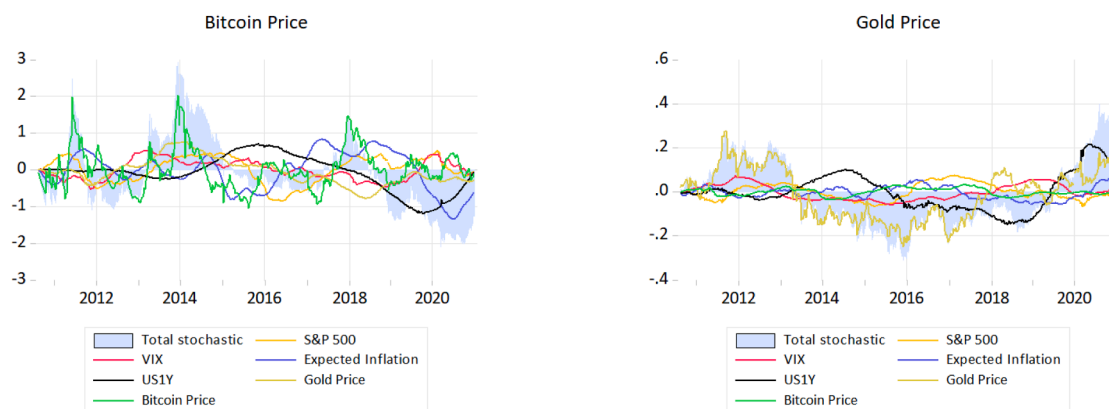
Note: This graph shows the historical decomposition of Bitcoin and gold prices for the sample period between July 21, 2010, and December 31, 2020.

Fig. 4. Historical decomposition of Bitcoin and gold prices
Note: This graph shows the historical decomposition of Bitcoin and gold prices for the sample period between July 21, 2010, and December 31, 2020.

rate.[13]

The bottom panel in Fig. 2 shows the estimation results of gold prices that are sharply contrasting from those of Bitcoin prices. Gold prices decrease in response to the S&P 500 index, implying that gold is qualified as a hedge for stocks. Moreover, gold prices increase significantly to the shock to the VIX, indicating that gold is qualified as a safe-haven asset. Gold prices do not respond much to the inflation shock but decrease significantly following the interest rate shock, which is also distinct from the case of Bitcoin. These findings suggest that Bitcoin acts nothing like gold in response to various shocks hitting the economy, thereby rejecting the popular claim that Bitcoin is a safe haven or "new gold."

The forecast error variance decomposition of Bitcoin and gold prices, shown in Fig. 3, provides further insight into the nature of Bitcoin price dynamics and highlights the contrast from gold price dynamics. For example, inflation expectation shocks explain an important share of Bitcoin price fluctuations, whereas they explain only a minor share of gold price fluctuations.

A historical decomposition of Bitcoin and gold prices is provided in Fig. 4, showing fluctuations in prices of Bitcoin and gold that are attributed to the shocks over the sample period. One can find an interesting pattern in Bitcoin price dynamics. While the increase in Bitcoin prices is dominantly explained by a shock to Bitcoin price itself, the decrease is relatively well-explained by other shocks—except for the beginning of the sample period—, especially by the VIX and expected inflation. This is in sharp contrast to gold price dynamics, which do not show much asymmetry between a bullish and bearish market and are dominantly driven by the U.S. monetary policy recently. The asymmetry in Bitcoin price dynamics that we document is consistent with Makarov and Schoar (2019), who find that idiosyncratic components of Bitcoin trading volume can explain arbitrage spreads between Bitcoin exchanges, particularly when Bitcoin appreciates. Apart from fundamental differences between Bitcoin and gold regarding their intrinsic value, concerns about the complexity and opaqueness of Bitcoin markets might explain the difference. For example, Gandal et al. (2018) identify price manipulation in the Bitcoin exchange.

Fig. 5 shows the estimation results parallel to Fig. 2 but using a high-frequency online price index to capture inflation shocks directly. While investors often claim Bitcoin as a hedge against monetary stimulus prevalent during and after the Global Financial Crisis as well as during the recent COVID-19 pandemic, the inflation-hedging property has not been directly tested due to the lack of realized inflation data at a high frequency. Although high-frequency financial data from the TIPS market is useful in extracting financial market participants' expectations about future inflation, it might not necessarily capture actual inflation relevant to the public. To guard against this possibility, we replace the inflation expectation variable with the actual high-frequency price variable.[14] Bitcoin and gold prices respond to inflation shocks similarly to how they respond to inflation expectation shocks, further confirming the inflation-hedging property of Bitcoin.

2.3.1. Financial vs. economic policy uncertainty

We replace the VIX index with the U.S. EPU index, developed by Baker et al. (2016), given the increasing attention paid to the predictive power of EPU on Bitcoin prices (Demir et al., 2018; Wu et al., 2019). While uncertainty about financial markets is followed by a decline in Bitcoin prices, Fig. 6 shows that uncertainty about future government policy does not have any negative effect. This finding echoes the claim that the increasing popularity and rapid appreciation of Bitcoin prices are largely driven by its independence

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[13] The negative finding might be driven by the binding ZLB constraint during most of our sample period. We test the possibility of this case by using the shadow short rate in Appendix.
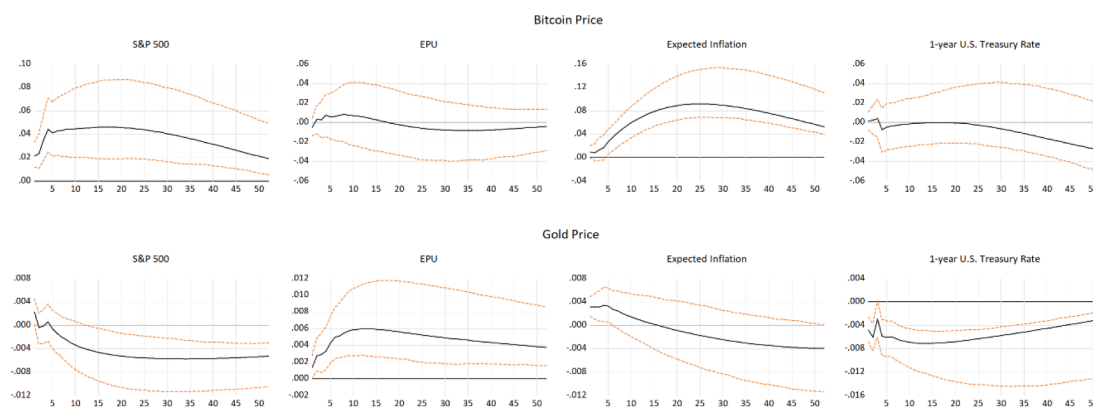[14] Due to the availability of the OPI, this exercise uses data up to April 11, 2018, which does not include the pandemic-related crisis.
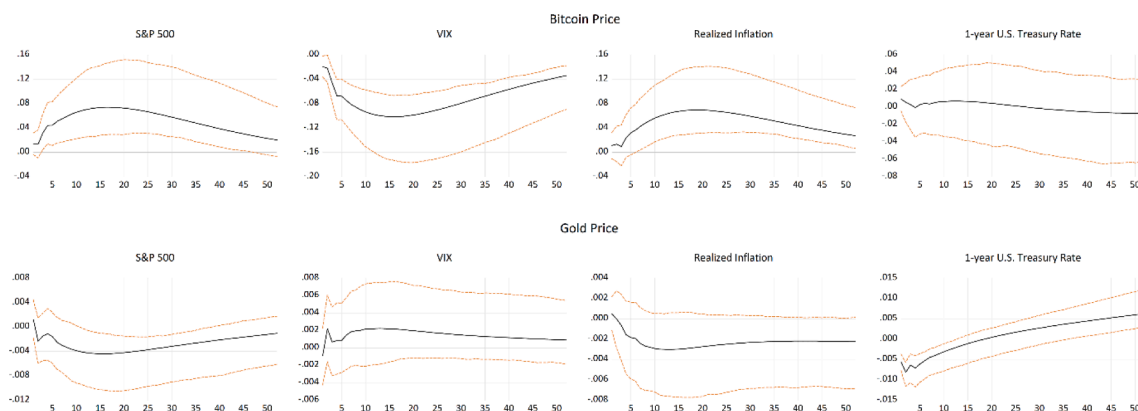
Note: This graph shows impulse responses of Bitcoin and gold prices to the one-standard-deviation shock in other variables and their 90% confidence bands from the six-variable VARs using the OPI instead of inflation expectation derived from the financial market data. The sample period covers from July 21, 2010 to April 11, 2018. The units of the horizontal axes are a week. The graphs on the top illustrate the response of Bitcoin prices, and the graphs on the bottom illustrate the response of gold prices.

Fig. 5. The response of Bitcoin and gold prices: using the OPI

Note: This graph shows impulse responses of Bitcoin and gold prices to the one-standard-deviation shock in other variables and their 90% confidence bands from the six-variable VARs using the OPI instead of inflation expectation derived from the financial market data. The sample period covers from July 21, 2010 to April 11, 2018. The units of the horizontal axes are a week. The graphs on the top illustrate the response of Bitcoin prices, and the graphs on the bottom illustrate the response of gold prices.

Note: This graph shows impulse responses of Bitcoin and gold prices to the one-standard-deviation shock in other variables and their 90% confidence bands from the six-variable VARs for the sample period between July 21, 2010, and December 31, 2020. The units of the horizontal axes are a week. The graphs on the top illustrate the response of Bitcoin prices, and the graphs on the bottom illustrate the response of gold prices. We use the baseline specification but replace the VIX with the EPU index.
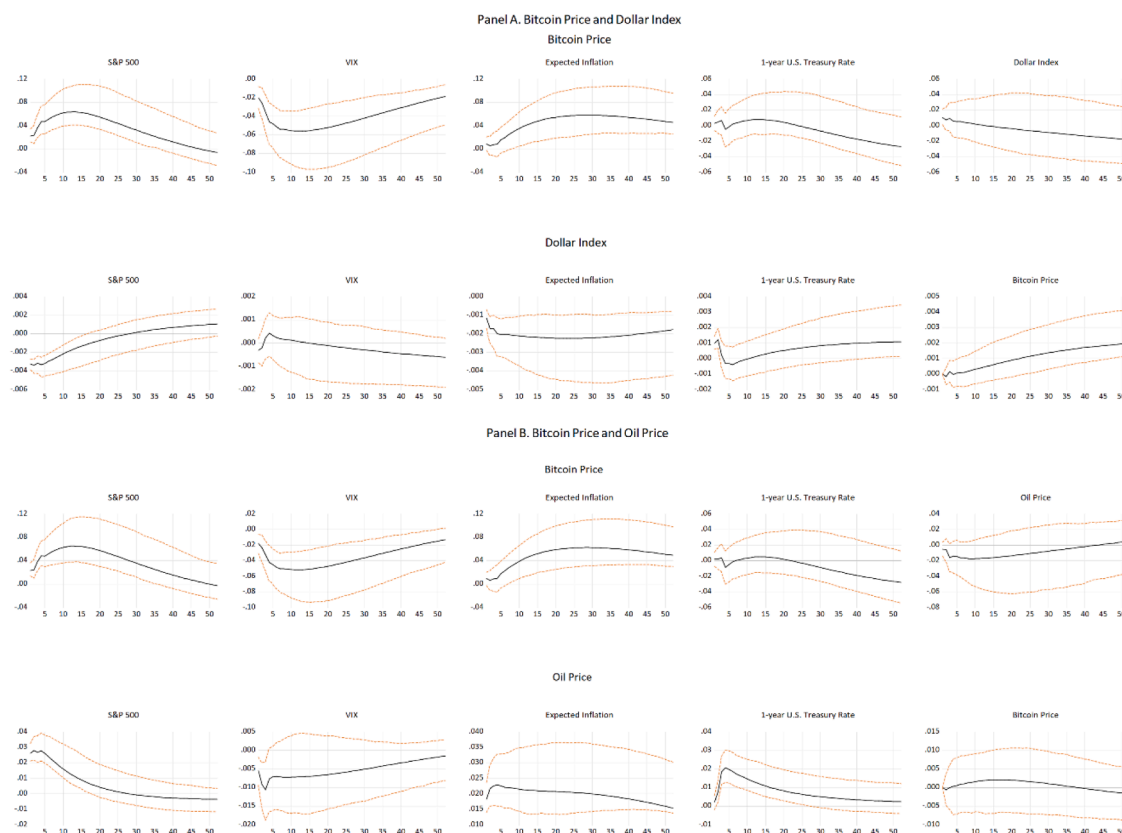
Fig. 6. The response of Bitcoin and gold prices: using the EPU

Note: This graph shows impulse responses of Bitcoin and gold prices to the one-standard-deviation shock in other variables and their 90% confidence bands from the six-variable VARs for the sample period between July 21, 2010, and December 31, 2020. The units of the horizontal axes are a week. The graphs on the top illustrate the response of Bitcoin prices, and the graphs on the bottom illustrate the response of gold prices. We use the baseline specification but replace the VIX with the EPU index.

from government authorities.

2.3.2. Alternative benchmark assets other than gold

We find that the responses of Bitcoin prices to various structural shocks are sharply different from those of gold. To enhance our understanding of Bitcoin price dynamics, we compare the empirical properties of Bitcoin with those of other well-known financial assets.

Fig. 7. The response of Bitcoin prices: model with the dollar index and oil prices
Note: This graph shows impulse responses of Bitcoin and gold prices to the one-standard-deviation shock in other variables and their 90% confidence bands from the baseline model but replacing gold prices with the dollar index (Panel A) and oil prices (Panel B). The units of the horizontal axes are weeks.

First, following much of the literature on the link between Bitcoin and traditional currencies (Yermack, 2015; Baur et al., 2018; Urquhart and Zhang, 2019), we replace gold prices with the U.S. dollar index, which measures the value of the dollar against a basket of foreign currencies. Panel A of Fig. 7 shows that the responses of the dollar index are sharply different from those of Bitcoin prices.

Second, Gronwald (2019) argues that Bitcoin behaves similarly to commodities like crude oil and gold, as Bitcoin shares characteristics such as the fixed supply with exhaustible resource commodities. Given a much longer history of crude oil and gold traded in financial markets, he emphasizes the importance of understanding commodity price dynamics to shed light on Bitcoin price dynamics. We also compare the response of Bitcoin with that of crude oil prices in the VAR model. Consistent with Gronwald (2019), oil prices respond to the S&P 500 and inflation expectations positively and respond to the VIX negatively (Panel B of Fig. 7).[15] Our findings, in general, differ from those of Liu and Tsyvinski (2018), who used factor analysis to determine that cryptocurrencies have no exposure to common stock market factors or the returns to commodities and currencies.

2.3.3. Robustness checks

Section B in Appendix provides a battery of sensitivity tests of our findings, including employing the alternative identification schemes, daily data frequency, alternative variables in the VAR model, different benchmark assets, excluding the COVID-19 pandemic period, and considering structural breaks in the Bitcoin market. The estimation results are summarized in Appendix for the sake of brevity, but our key findings are robust to an exhaustive set of sensitivity checks.

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[15] We find qualitatively similar results when using the commodity price index instead.

3. Conclusion

Despite the many interesting empirical regularities discovered in the paper, our results are subject to some caveats. First, while the main findings, including a battery of sensitivity tests, shed new light on Bitcoin price dynamics, the rapidly changing environment regarding cryptocurrency markets urges caution in interpreting our findings. Especially, we have ignored any impact on Bitcoin prices of regulatory changes or the increasing number of new cryptocurrencies available. Second, compared to previous analyses of other safe-haven assets such as gold, the sample period in our analysis is limited to the early stages of cryptocurrency market development. Thus, important market characteristics, such as trading volume or liquidity, may suddenly change in the future, which would challenge our findings. A fruitful direction for future research should provide a fully coherent theoretical and empirical framework encompassing both the currency- and asset-like features of cryptocurrencies.

Author contribution statement

Bitcoin: An Inflation Hedge but Not a Safe Haven (by Sangyup Choi and Junheok Shin)
Sangyup Choi: Conceptualization, Formal analysis, Methodology, Writing – original draft, review & editing
Junhyeok Shin: Data curation, Formal analysis, Software, Writing – original draft

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.frl.2021.102379.

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